REMARKS

The subject invention relates to an improved approach for laser machining. It has been found experimentally that laser machining processes where material is removed from a workpiece (such as cutting, grooving, drilling or etching procedures) can be improved by applying a thin flowing layer of liquid across the surface of the material. This process is optimized when the flowing liquid layer has a thickness between 25 and 100 microns. If the layer is too thick, efficiency and ablation rates will be reduced. If the layer is too thin, it will vaporize upon heating and not produce the sonic cavitation associated with the improved material removal performance in the liquid.

In the Final Office Action, the Examiner rejected the two independent apparatus claims 1 and 37. Both of these claims included a mechanism for creating a flowing layer of liquid having a thickness in the range of 25 to 100 microns. The Examiner rejected these claims based on prior art devices which the Examiner argued were "inherently capable" of generating such a liquid layer thickness. Further, the Examiner interpreted Applicant's apparatus claims as "not limited to use only with a layer thickness of 25 to 100 microns." Specifically, the Examiner stated that Applicant's recitation of a particular layer thickness in the claims only defines an "intended use that merely requires the presence of a layer forming means that is inherently capable of forming a layer of the recited thickness." (see page 10 of the Office Action).

The Applicant understands the Examiner's logic but respectfully disagrees. In particular, the concept of "inherency" with respect to the operation of a prior art device has been narrowly construed by the courts. Accordingly, a "result" that is alleged to be inherent in a prior art device must not merely be possible (capable of being performed) but must in fact actually occur during the operation of the prior art device (MPEP 2112). Further, with regard to Applicant's claims, it is submitted that the limitations set forth therein, particularly in claim 1, which specified a flow control means for creating a particular liquid layer thickness, defines a functional limitation that is much more than a mere recitation of "intended use." For these reasons, Applicant still believes that claims 1 and 37 are patentable and Applicant reserves the right to pursue claims of similar scope in a subsequent continuation case.

Recognizing the disagreement with the Examiner and wishing to expedite prosecution without the need for appeal, Applicant has filed a new set of method claims in conjunction with a Request for Continued Examination (RCE). These method claims (91 to 107) are submitted to

directly address the Examiner's reasons for rejection. More specifically, in a method claim context, a recitation of a step of directing a liquid flow in a manner to establish a flowing liquid layer having a thickness of 25 to 100 microns unquestionably limits the claim to such operation and is not merely an "intended use." Such a limitation also obviates a rejection over a prior art device that might be only "inherently capable" of creating such a layer since one can obtain a patent on a new method of using an old device. Stated differently, in order to reject a method claim reciting a particular operating regime, it is insufficient to merely show that a prior art device was inherently capable of operating in that regime. To establish a prima facie case of obviousness, the Examiner must show either that the prior art device actually operated in that fashion or there was a teaching or suggestion that the device should be operated in that fashion.

Applicant has also taken this opportunity to address some of the other perceived omissions in the claims noted by the Examiner. More specifically, the Examiner (at page 11) interpreted claim 1 as merely a spray coating devices without a laser. The new claims are specifically directed to a method of removing material from a workpiece with a laser beam.

In addition, the Examiner apparently was interpreting the concept of "machining" as any form of processing. In this regard, the Examiner pointed to a paragraph in the specification which mentions operating below the laser ablation threshold. It should be noted that this single paragraph was related to one specific concept where chemical compounds are added to the liquid layer so that the chemical compound can effect the material interaction. In this case, where one relies on the added effect of the chemical interaction, it might be desirable to operate the laser "at or below the ablation threshold." Other than that sole paragraph, the remainder of the specification is clearly directed to material removal including cutting, grooving, drilling or etching procedures (page 8, paragraph 32.) See also the reference to "ablation particulates" in paragraph 34, "eliminating debris generated in the ablation process" in paragraph 38. New claim 91 specifies material removal in one of a cutting, grooving, drilling or etching procedures. This limitation will help distinguish over the many references relied on by the Examiner that are merely configured to clean particulates off the surface of the workpiece without damaging the workpiece.

Turning to the specifics of the Office Action, it is noted that the Examiner rejected claims 16 and 17. Since these claims have been cancelled, this rejection is now moot. Claims 1-20 were rejected as not being supported by the specification because the claims referred to a "fluid"

layer rather than a "liquid" layer. It should be noted that new claim 91 refers only to a liquid layer, not a fluid layer, thereby addressing the concern of the Examiner.

It is respectfully submitted that new independent claim 91 is not anticipated or rendered obvious by any of the prior art of record in this case. Since the Applicant has filed a new claim set, the specific combinations of the prior art argued by the Examiner to demonstrate a prima facie case of obviousness against the previous claims are not directly or easily addressed. Applicant, however, will discuss the each of the references to demonstrate that they do not teach the invention as now currently claimed.

As noted previously, the Tam article (J. Appl. Phys, April 1992) and the Zapka article (Efficient Pulsed Laser Removal of 0.2 Micron Sized Particles from a Solid Surface) relate to laser cleaning techniques. In both of these techniques, the authors use an extremely thin liquid layer, on the order of a micron in thickness (see the Abstract of both articles). In this technique, the laser light is used to superheat the very thin liquid layer, causing "explosive evaporation" resulting in cleaning of the surface without damaging the underlying substrate. Tam and Zapka clearly fail to teach a method of material removal wherein the thickness of the liquid layer is "in the range of 25 to 100 microns." As noted above, even if the Examiner were correct that the devices in Tam or Zapka might be capable of creating a liquid layer having a thickness in the claimed range, absent such a teaching or suggestion, new method claim 91 cannot be rejected. In this regard, it should be noted that one skilled in the art would view Tam and Zapka as **teaching away** from this thicker liquid layer since a thicker liquid layer could lead to damage to the workpiece (semiconductor wafer).

The Zhu article (Laser Ablation of Solid Substrates in a Water-Confined Environment) relates to laser ablation of materials using a "water confinement regime (WCR)" configuration. In this approach, the workpiece is placed in a glass cuvette and submerged under a static water layer. Zhu reports optimal results when the static water layer has a thickness of 1.1 mm. With this thickness, Zhu achieves an ablation rate of 62 nm/pulse. Zhu also reports experiments with a thinner static water layer, created by water vapor condensation. Experiments with the thin (about 50 micron) layer achieved an ablation rate of only 19 nm/pulse. Zhu suggests that this poor performance is because the plasma cannot be tightly confined within the water layer (page 1397, top of second column). In fact, Applicant believes the poor results achieved by Zhu with a thin water layer was because it was a static layer and not a flowing layer as in Applicant's invention.

The Examiner argues that Zhu demonstrates that Tam would be capable of operating with a water film of 50 microns. As noted above, even if that were true, it would not render claim 91 obvious because one skilled in the art would not be motivated to operate Tam with a thicker layer because of fears of damaging the wafer.

The Examiner cited the patent to Elliot (5,669,979) for its teaching of computer controls as well as filtering and recirculating liquids. Elliot is directed to a system for removing photoresist from the surface of a wafer. In one embodiment, a liquid having a reactant such as hydrogen peroxide is passed over the substrate. Elliot suggests a liquid depth in the range of 0.5mm to 20mm, much thicker than the thickness range set forth in claim 91 (see, column 18, line 67+). The teachings of Elliot cannot overcome the deficiencies of the primary references in rendering obvious Applicant's invention as defined by new claim 91.

The patents to Moore (5,601,107) and Johnson (5,622,622) were cited with respect to claim 17 relating to the reservoir holding at least one light reactive chemical. Claim 17 has been cancelled and the subject matter thereof has not been incorporated into the new claims. The teachings of Moore and Johnson cannot overcome the deficiencies of the primary references in rendering obvious Applicant's invention as defined by new claim 91.

The Roth, Uziel and Drzal references were cited for their teaching of spraying atomized liquids. (Roth II-Specific Surface Treatment by Laser Irradiation Under Fluid Films, Uziel (6,827,816) and Drzal (6,565,927)).

Roth discloses a laser machining systems where a liquid film is applied to the workpiece during laser irradiation. Roth estimates the film layer "to be several 100 microns thick." The Examiner argues that Roth states that measuring layer thickness is problematic because of bubble formation. While that may be true, it is also true that Roth nowhere suggests that his performance might be enhanced be operating with a layer thickness below 100 microns.

Uziel relates to a particle removal system. Uziel suggests depositing a vapor film on the substrate which condenses into a liquid film. Uziel fails to discuss the thickness of his film that is created via this approach. However, it is likely that the layer is quite thin since he states that the liquid film "explosively evaporates" in response to the laser irradiation, a description which is consistent with the very thin films described by Tam and Zapka discussed above (see, column 7, line 53 of Uziel).

The patent to Drzal was cited for its teaching of using steam during surface treatments. In the Drzal system, radiation is provided by a UV generating flashlamp rather than a laser. In one embodiment, water is sprayed onto the surface of the workpiece to create "very small droplets, less than1 micron in diameter." (column 9, line 24+) Alternatively, Drzal suggests using a very thin continuous layer of water.

It is respectfully submitted that the teachings of Roth, Uziel or Drzal, whether taken alone or in combination, fail to overcome the deficiencies of the primary references in rendering obvious Applicant's invention as defined by new claim 91.

In the Office Action, the Examiner also relied on the patent to Franca (6,178,973). Franca relates to an apparatus which uses a single optical source to generate ozone and for treating the surface of a semiconductor wafer. Franca also discloses directing a stream, which may be liquid, to the substrate. Franca mentions the possibility of creating a condensate at the surface. Franca fails to disclose creating a flowing liquid layer much less a layer having a thickness between 25 and 100 microns. As noted above, even if the Examiner were correct that Franca was inherently capable of creating such a layer, that would be insufficient to render claim 91 obvious without some suggestion that a liquid layer of that thickness is desirable for material removal.

The Examiner also relied on the patent to Uziel (Uziel II – WO 00/38935) for its teaching of a "fluid" flow. Uziel II teaches laser particulate removal in the presence of a flowing gas, not a flowing liquid. Uziel II neither teaches, nor is it capable of creating a liquid flow layer having a thickness between 25 and 100 microns. The Examiner cited the patent to Yogev (6,627,846) for its teaching of treating a workpiece with steam and a light reactive chemical. Yogev, which relates to removing particles in the presence of an explosive medium to generate a blast wave and create a reactive species, fails to overcome the deficiencies of the primary references in rendering obvious Applicant's invention as defined by new claim 91.

The Examiner also relied on Roth I (Novel Technique for High-quality Microstructuring with Excimer Lasers). Roth I, like Roth II teaches using a relatively thick liquid layer. For the reasons set forth above with respect to Roth II, Roth I fails to overcome the deficiencies of the primary references in rendering obvious Applicant's invention as defined by new claim 91.

In summary, it is respectfully submitted that the Applicant was the first to discover the benefits which can be achieved when removing material from a workpiece with a laser beam in

the presence of a flowing liquid having a thickness of 25 to 100 microns. There is simply no teaching in the prior art that a layer of flowing liquid in this thickness range would provide special benefits. Since the invention is now defined in terms of a method, the argument that a prior art device was "inherently capable" of operating in the fashion claimed is insufficient to reject the claim. The Examiner must demonstrate that one skilled art would either operate such a device in this fashion or would be motivated to operate the device in this fashion. It is respectfully submitted that none of the prior art contains such a suggestion and if anything teaches away from using these parameters. In view of the above, it is submitted that new independent method claim 91 defines patentable subject matter and allowance thereof, along with the claims depending therefrom, is respectfully requested.

Respectfully submitted,

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Dated: June 4, 2006

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